SAMMAMISH RIVER F.L.I.R. STUDIES IN SEPTEMBER 1999 AND MARCH 2000

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Introduction

Forward Looking Infrared (FLIR) has been demonstrated as a reliable, cost-effective, and accessible technology for monitoring and evaluating stream temperatures from the scale of watersheds to individual habitats (Karalus et al., 1996; Norton et al., Faux et al., 1998). In 1999 and 2000, the US Army Corps of Engineers in Seattle, Washington contracted with Watershed Sciences, LLC to map and assess stream temperatures in the Sammamish River using FLIR.

Traditional methods for monitoring stream temperatures have relied on instream temperature monitors to gather data. These monitors provide temporally continuous data, but provide little insight into the spatial variability in temperatures. With the use of remote sensing, we have been able to map stream temperatures across entire stream networks at a point in time. FLIR technology has proven to be a highly portable and cost-effective method to collect very detailed data over large areas in very little time. The combination of temporally and spatially continuous data provides very powerful tools for understanding the dynamics of stream temperature hierarchically across multiple scales (pools → reaches → streams → watersheds). Current research has identified cool versus warm streams within a watershed, cool reaches within a stream, and cool habitats within a reach (McIntosh et al., 1995; Torgerson et al., 1995; Torgerson et al., 1999).

Two FLIR flights were performed on the Sammamish River to try and identified any underground water sources that could cause warmer or cooling effect on the river. One FLIR flight was performed on March 23, 2000 and the second FLIR was performed on September 2, 1999.

March 23, 2000

FLIR and color videography were collected on the Sammamish River between Lake Washington and Lake Sammamish on March 23, 2000. The images were sampled in a GIS environment to develop a longitudinal temperature profile for the surveyed reach during the relatively high flow, cool temperatures typical of winter conditions. The objective of the project was to assess the imagery for areas of potentially high groundwater discharge to the Sammamish River. Areas of high groundwater discharge would be potential indicators of strong floodplain connectivity and become priority areas for protection and restoration.

Assessment of the stream temperature pattern in the study reach during the winter indicates that thermal conditions are fairly uniform along the study reach. Stream temperatures ranged between 7.3 and 8.7ºC over the length of the survey. We found no evidence of point source discharges of groundwater or sub-surface flow anywhere in the study reach. This may be due to the overlap in stream temperatures (7.3 to 8.7ºC) with the likely range of groundwater temperature (7 to 10ºC), making the detection of groundwater very difficult. We had predicated this study on the likelihood that stream temperatures would be cooler (3 to 6ºC) allowing the detection of warmer groundwater discharges if they were present. There is also the possibility that significant groundwater inputs don't occur as point source inputs in the Sammamish River. Our comparison of the summer and winter longitudinal temperature profiles indicated that the coolest stream temperatures occurred in the same reach. This reach occurred just downstream of North Creek and coincided with the shift in valley geomorphology from floodplain dominated to hillslope control. The transition from a valley geomorphology to a hillslope geomorphology may have had the effect of forcing the down valley movement of groundwater to move from the floodplain to the main channel and causing the cooling of stream temperatures. This is a possible mechanism, but additional study of longitudinal discharge patterns will need to be conducted to determine if this is the cause of cooler temperatures in this downstream reach. Conducting simultaneous measurements of stream discharge at regular intervals, such as every mile, along the channel profile should indicate where discharge is increasing rapidly. Once the effect of tributary inputs are accounted for it should become apparent whether the reach transition described above are influencing discharge patterns in the study area.

September 2, 1999

FLIR and color videography were collected on the Sammamish River between Lake Washington and Lake Sammamish on September 2, 1999. The images were sampled in a GIS environment to develop a longitudinal temperature profile for the surveyed reach. We believe that these data provide an accurate representation of the temperature patterns in the study area during summer low-flow conditions. Previous research in eastern Oregon demonstrates that while absolute temperatures may vary on a daily and seasonal basis, the summer low-flow longitudinal pattern remains unchanged (B.A. McIntosh, *unpublished data*).

Assessment of the stream temperature pattern in the study reach indicates the warmest temperatures occur at the outlet to Lake Sammamish with temperatures generally decreasing in a downstream direction until river kilometer 4.4, where temperatures increase until the confluence with Lake Washington. Our analysis indicates tributaries contribute generally cooler flows, with Bear Creek having a significant effect on stream temperatures. We noted a few local thermal features in the study reach contributing warmer habitats to the overall thermal environment, but in general a lack of thermal heterogeneity at the scale of habitat units (e.g., pools and riffles). The data suggests that the in-flow from Lake Sammamish and Bear Creek appear to be the dominant influences on stream temperatures for this reach of the Sammamish River. Lake Sammamish controls the initial thermal conditions in the Sammamish River and cool inflows from Bear Creek seem to moderate the relatively warm inflows from Lake Sammamish. Further study of the processes that may be influencing thermal conditions in Lake

Sammamish seems warranted. These would include tributary influences on the lake and the manipulation of outflows from the lake. While surface inflows appear to exert significant control over longitudinal temperature patterns, review of the color videography indicates little or no shading of the stream channel by riparian vegetation over most of the study reach. The restoration of stream temperatures in the study area will require more thorough investigation of the historical distribution and composition of riparian vegetation and its current and future potential for recovery.

Follow-on

The FLIR imagery provides a snapshot of the stream temperature patterns at the time of the survey. A complete explanation for these temperature patterns requires a better knowledge of the basin and the processes that may affect stream temperatures. This database provides a method to develop detailed maps and analysis of stream temperatures at multiple scales, dependent on the question of interest.

The following is a list of potential uses for these data in follow-on analysis:

1) The patterns provide a spatial context for analysis of temporal temperature data from seasonal in-stream data loggers and the future distribution of the monitors. How does the temperature profile relate to seasonal temperature extremes? Are local temperature maximums consistent throughout the summer and between years?

2) What is the temperature pattern within critical reach and sub-reach areas? Are there thermal refugia within these reaches that are used by cold water fish species during the summer months?

3) The FLIR and Day TV images provided with the database could be aggregated to form image mosaics. These mosaics are powerful visual tools for planning fieldwork and for presentations.